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Driving force analysis of landuse and cover changes in Cimandiri and Cibuni Watersheds

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Abstract

West Java in north region around Jakarta has been developed and constantly accelerating. This development has caused many problems i.e. floods, land slide, erosion and pollution. In contrast, the development of West Java in south region is very slow, although there are many potential lands to be developed. Environmental degradation in a landscape should be considered in a watershed as it has function as ecological boundary. Two watersheds which are located in south region, namely Cimandiri and Cibuni watershed are less developed than the watersheds in the north region. Learning from the north region development condition which caused environmental degradation, south region watersheds should consider the environmental aspects in the development process. Therefore, landscape planning to explore the watershed resources potential and landscape management is needed by considering the environmental impacts for supporting the low carbon societies (LCS) program. The purposes of this research are to analyze land use/cover changes (LUCC), and to determine the driving factor of these changes. Supervised classification and logistic regression analysis (LRA) were employe in this study.. We found that there are three land use and cover classes that dominate Cimandiri and Cibuni Watersheds such as farm fields, forest, and bushes.

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Keywords: geographic infomation system; Landsat image; landuse and land cover change; watershed management

1. Introduction

North region West Java development such as Jakarta city is constantly accelerating which is contrary with the development in south region of West Java (i.e. District of Sukabumi, Garut, Tasikmalaya, and Cianjur) which is very

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slow, although there are many potential lands for development [1, 2]. The development itself has caused many problems in terms of ecological condition [3, 4, 5]. The ecological degradation and disasters should be analyzed as the correlation of the watershed development [6].

In south region of West Java, there are two watersheds that adjacent to each other, which are Cimandiri and Cibuni watersheds that flow from Gede-Pangrango and Salak mountains. The condition of those watersheds are not developed well [7]. A good planning and development must be conducted by the local government, by referring to the previous year developments and analyzing the driving force factors of the development itself [8]. The watershed function as provider of ecosystem service [9, 10] should be also considered for supporting the low carbon societies (LCS) [11]. The LCS is part of a research project published by Britain and Japan in 2006 Kyoto Protocol. In order to get the information about the development changes and its driving factors, a spatial approach is necessary to identify the land use/cover change (LUCC) in the three previous decades, and to analyze the driving forces of changing.

2. Methodology

2.1. Location, Tools, and Materials

This study was located in Cimandiri and Cibuni Watersheds (Figure 1). The tools used in this study consist of hardwares, which are digital camera, GPS and several geography information system (GIS) softwares. Materials used in this study are Landsat images of year 1978, 1996, and 2012 (Table 1). Sub-district administrative boundary map, watershed boundary map, precipitation map, digital elevation model (DEM), soil type map, and demography data. This study used technology to identify LUCC in Cimandiri and Cibuni watersheds periodically, identify the land use and cover changes, and analyze the change's driving factors.

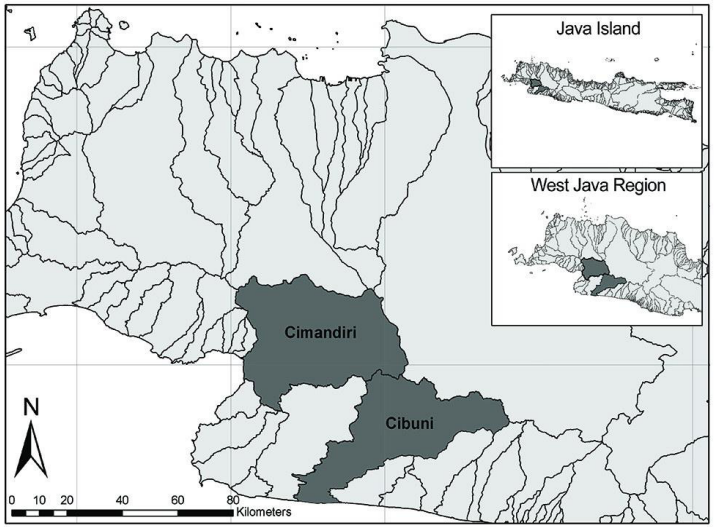

Fig. 1. Cimandiri and Cibuni Watersheds location

Table 1. Landsat data acquisition

Landsat Data	Acquisition Date
LANDSAT1 MSS	July 17th, 1978 Path 131 Row 065
	July 17th, 1978 Path 130 Row 065
LANDSAT5 TM	August 8th, 1995 Path 122 Row 065
	July 25th, 1996 Path 122 Row 065
LANDSAT7 ETM+	May 26th, 2012 Path 122 Row 065

2.2. Methods

The main method used in this study was supervised classification for land use and cover identification and logistic regression analysis was used for driving force analysis. Land use and cover that that has been classified in this study are (1) water bodies, (2) forest, (3) agricultural areas, (4) vacant land, (5) built up area, (6) farm field, (7) bushes, and (8) cloud. The factors analyzed in the study by using logistic regression analysis (LRA) are (1) rainfall, (2) soil type, (3) slope, (4) population, (5) population density, and (6) distance to urban area.

3. Results

3.1. Landuse and Cover Classification

Based on Figure 2 and Table 2, Cimandiri and Cibuni watersheds are dominated by bushes (light green), agricultural field (yellow), and forest (dark green). It shows that both watersheds are not yet developed for urban areas. Furthermore, the built-up areas in both watersheds are less than 5% in total. It could be assumed that the region of Sukabumi still maintains its agricultural economic characteristics, where agriculture is still dominating the local economy and activities.However, farm fields, forest, and bushes have been dominating for both watersheds.

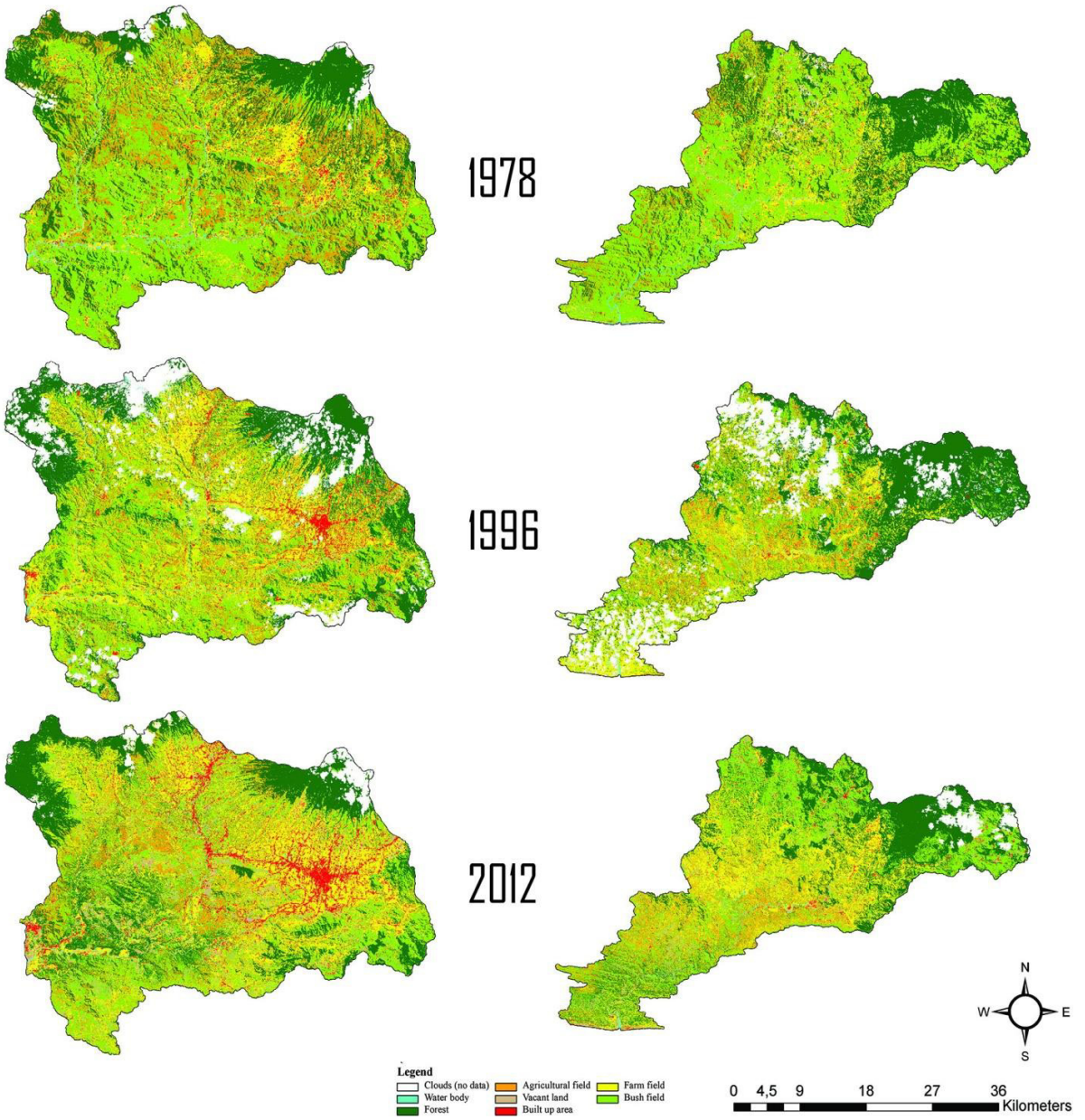

Fig. 2. Cimandiri and Cibuni Watersheds landuse classification in 1978, 1996 and 2012

Table 2. Landuse and cover area in Cimandiri and Cibuni watersheds

Landuse Classification	3.1.1. Cimandiri Watershed (ha)			3.1.2. Cibuni Watershed (ha)		
	1978	1996	2012	1978	1996	2012
Cloud	3.127,32	20.623,59	4.093,56	1.135,44	26.093,34	4.014,81
Water bodies	1.586,52	1.511,19	674,19	1.067,04	1.296,18	583,20
Forest	40.755,96	38.981,34	39.576,51	35.085,24	41.499,81	35.650,53
Agricultural field	33.144,12	12.888,63	14.164,83	12.208,68	9.419,94	10.986,03
Bare land	1.605,24	812,16	10.845,63	1.080,00	433,80	5.581,44
Built up area	2.973,60	7.326,81	11.659,95	831,24	2.687,49	2.550,96
Farm field	24.234,48	53.452,17	59.302,62	24.194,16	33.482,88	41.237,01
Bushes	76.350,24	47.877,12	43.155,90	68.497,92	28.783,98	43.094,79

3.2. Landuse and Cover Identification and Changes

The percentage of land use changed (Table 3) in Cimandiri watershed from 1976 to 1996 is 61% and 56,43% from 1996 to 2012, while in Cibuni watershed was 60,54% in 1978 to 1996 and 55,77% in 1996 to 2012. Both watersheds were still less developed, since the built-up area percentage is less than 5%. The LUCC in Cimandiri watershed was started to change to about 61% during 1978-1996, and about 56,43% in 1996-2012, while in Cibuni watershed was changing 60,54% in 1978-1996 and 55,77% in 1996-2012. Based on this result, it can be stated that LUCC in both watersheds were significantly changing during three decades.

Table 3. The diagram of LUCC changing from 1978, 1996 and 2012

Period	LUCC Changing	Cimandiri		Cibuni	
		Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
1978-1996	Unchanged	63,097.20	39.00	46,073.70	39.46
	Changed	98,645.13	61.00	70,675.29	60.54
	Total	161,742.33	100.00	116,748.99	100.00
1996-2012	Unchanged	69,993.72	43.57	50,461.38	44.23
	Changed	90,637.65	56.43	6,616.41	55.77
	Total	160,631.37	100.00	114,077.79	100.00

The main transportation in Cimandiri Watershed was by using water transportation. The people used Pelabuhan Ratu Harbor at the west side of the watershed to move from their location to northern area. It was due to the main road were not developed yet. Meanwhile, the settlement in Cibuni Watershed mostly located in the upland, close to the mount. Compare to Cimandiri Watershed, the accessibility in Cibuni Watershed was more difficult. Therefore, the accessibility can be assumed as the main reason why both watersheds were less developed.

In 1996, Sukabumi District is classified as a conventional (or traditional) region where industrial sectors contribution was less than 10%. It can be assumed that at this period bushes were dominated land utilization then changed to farm land. The development of settlement and built-up areas were also increasing about 4% in Cimandiri Watershed and 2% in Cibuni Watershed.

In 2012, industrial sector were developing in compliance with agricultural sector. The increasing of built-up areas were focused on around Sukabumi City and the main road to Bogor District. It indicated the increasing of human needs for land in this both watersheds, while in Cibuni Watershed was still lack of built-up areas because there were no big cities that accelerates or attracte people to urbanize.

3.3. Driving Force

Based on LRA results, the driving forces of LUCC for both watersheds showed that all of the six variables i.e. rainfall, soil type, slope, population, population density, and distance to urban areas wee significantly affecting the land use and cover changes for both watersheds. The LRA results showed that rainfall, soil type, slope and distance to urban area have negative correlation, while population and its density have positive correlation.

4. Conclusion

Based on this research, it can be concluded that there were three land use and cover classes that dominated Cimandiri and Cibuni Watersheds. They were farm fields, forest, and bushes. The LUCC were significantly changing from 1978 to 1996 and from 1996 to 2012, which was more than 50% of LUCC area. All of the six variables, i.e. rainfall, soil type, slope, population, population density, and distance to urban area were significantly affecting the land use and cover changes for both watersheds.

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